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Conference Report

NIST WORKSHOP ON PROCESS INFORMATION TECHNOLOGY: FROM RESEARCH TO INDUSTRY Gaithersburg, MD March 12-13, 1998

Report prepared by

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1. Introduction

The workshop, "Process Information Technology: From Research to Industry," was held on March 12-13, 1998 in Gaithersburg, Maryland, under sponsorship of the National Institute of Standards and Technology (NIST).

The purpose of the workshop was to bring together vendors, end users, and researchers from different manufacturing-related disciplines to discuss matters of common interest concerning process information technology (PIT). Interest in the advancement of PIT has grown dramatically over the past few years. PIT includes, but is not limited to, process modeling, analysis, execution, and monitoring as well as process information management and exchange. Recent research efforts have focused on identifying and defining the terminology related to manufacturing, enterprise, and workflow processes. The underlying premise is that with a common set of terms, or at least a common meaning of concepts behind those terms, process information will be easier to use, manage, and exchange. With much of this work still in its early stages, NIST hosted this workshop for researchers and practitioners to come together to determine what future directions these efforts should take to ensure they address the needs and challenges that companies are facing today and expect to face in the future.

2. Objectives

The primary objective of the workshop was to provide an open forum for researchers and industry representatives to discuss how current and future research efforts could further address the PIT needs of industry.

Specific workshop goals were:

- To identify, discuss, and propose solutions to issues in current technology with input from vendors, end users, and researchers in the PIT field;
- To raise the awareness of needs in the area of PIT and of current research efforts;
- To determine the need for standards for process information and the role of NIST in that effort; and
- To educate participants by providing an in-depth look at various aspects of PIT.

The workshop included presentations from researchers, vendors, and end users; break-out sessions to address specific needs of researchers, vendors, and users; and a seminar to explore in-depth issues pertaining to the advancement of PIT. The list of presentations is shown in Table 1. The next section presents the results of each of the four break-out groups.

Table 1. Topics presented at the NIST Workshop on Process Information Technology March 12-13, 1998

Presenter	Affiliation	Title of Presentation
Frank Boydstun, Jr	Tinker AFB	Process Knowledge Destinations
Paul Wu	Lucent Technologies	Process Methodology and Tool Standardization—An End User Perspective
Naresh Raja	Deneb Robotics	Industry Collaborative Technology Programs
Kurt Freimuth	Agiltech Inc.	Process Specification Language: A Justification
John Valois	STEPTools, Inc.	Process Information and EXPRESS
Mark Klein	Massachusetts Institute of Technology	Tools for inventing organizations: Toward a handbook of organizational processes
Perakath Benjamin	Knowledge Based Systems, Inc. (KBSI)	Process Information Technology Overview
David Hollingsworth	Workflow Management Coalition	Process Specification & Interchange: A WfMC Perspective
Craig Schlenoff	NIST	Process Specification Language: Overview and Current Status
Anne Jones	Wizdom Systems, Inc.	What we have here is a failure to communicate
Perakath Benjamin	KBSI	Methods and Tools for Process Analysis Presenter
Christopher Menzel	KBSI	Methods and Tools for Process Knowledge Representation and Acquisition
Perakath Benjamin	KBSI	Methods and Tools for Process Design and Implementation
Amit Sheth	University of Georgia	Overview of Workflow Management: Beyond Process Modeling

3. Process Information Technology Issues

The sub-sections below begin with the main question posed and the name of the facilitator for each break-out group.

3.1 Industry Needs and Research Efforts

Question: What are the current and future PIT needs of industry, and are research efforts addressing those needs?

Facilitator: Michael Gruninger

Discussion revolved around the following questions:

- What needs are research efforts currently addressing?
- Which future needs should research efforts address?
- What is the prioritization of these future needs? In particular, which needs are critical in the short and long term?
- What are the major efforts currently underway within the research community?
- What is the mapping between needs and research thrusts?
- How can we facilitate and manage the extraction of needs from industry and communicate them to the research community?

3.1.1 Taxonomy of Needs

The group began by attempting to provide a framework for categorizing industrial needs as a way of matching them to existing research efforts (see Fig. 1). The four major categories identified within the group were:

- The industry sector being supported by PIT
- The enterprise function being supported by PIT
- The specific information techology task being supported by PIT
- The motivation and objectives for using PIT

People working within different categories will have different needs with respect to PIT. A more comprehensive framework could possibly be developed and used as a means of extracting requirements from industry.

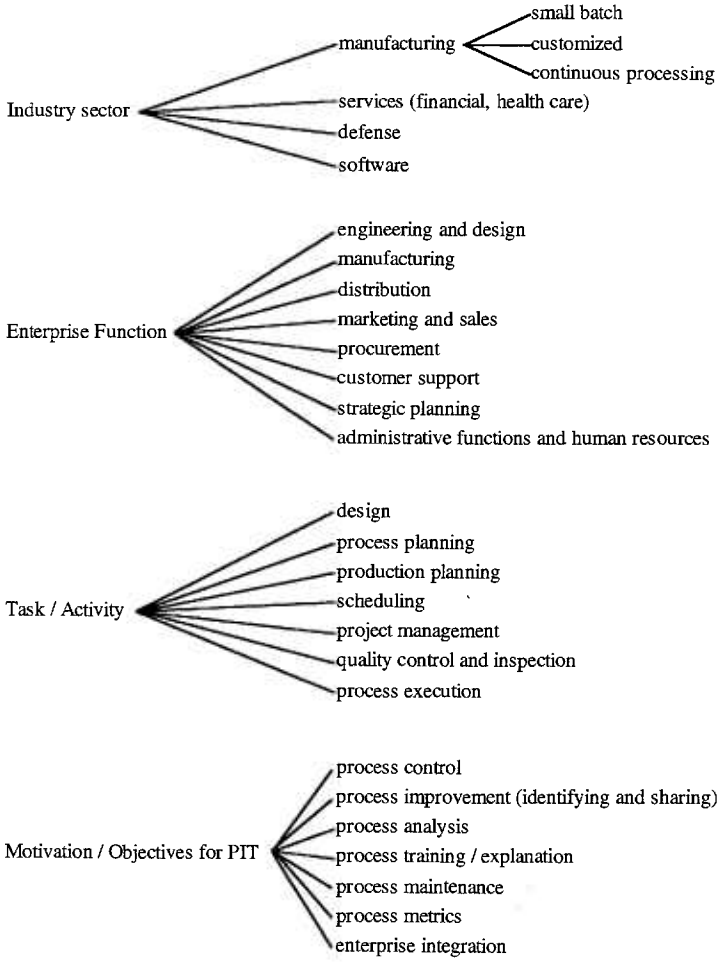

Fig. 1. Taxonomy of PIT industrial needs.

3.1.2 What's Missing in Current Research

Since we can only model what we can describe, much of the discussion focused on the problem of the limited expressiveness of existing approaches to process modeling.

- Soft Processes

Much research to date has focused on the tangible aspects of process design and analysis. But it has not adequately addressed the "people" side of the enterprise. Process technology must support the integration of organizations from the perspectives of people, organizational structure, processes, technology, and culture. This requires the ability to model and characterize soft concepts (such as social dynamics), as well as taking an interactive/collaborative approach to the current structural approach for process definition. Furthermore, there needs to be additional work in the specification and measurement of qualitative metrics for processes.

- Unstructured Environments

Although many process-modeling formalisms are very good at specifying predictable, deterministic processes, they often fail to capture the rich complexity of the practical world, particularly the ubiquity of non-determinism, unpredictable dynamics, and uncertainty. In particular, formalisms must be able to model unstructured environments with numerous (possibly unknown) variables. The modeler often does not know what stimuli are relevant or when they will occur. An interesting issue is the role of exception handling—current approaches deal with anticipated exceptions, but an even greater challenge will be an account of handling unanticipated exceptions.

- Process Intent

Little work has been done on the representation of process intent or rationale. This work is necessary for a proper integration of different process-modeling tools. An example is the relationship between the product designers and the process planners. The features of the product are the intended effects of the process plan, and if any aspect of the product design is changed, the process planners will need to know which activities within the process plan need to be modified.

- Lack of Integration

Existing process models are often loosely decoupled from the planning goals and constraints, as well as resource models. In addition, we need better integration between planning models and execution environments (the gap between planning and how the process actually works).

- Abstraction

We need models that operate at multiple levels of abstraction, particularly to support planning and execution.

- Change Management

We need a better understanding of change management—the migration from "as is" to "to be" process designs.

- Science of Process Modelling

A common theme throughout the discussion was the recognition of the need for a science and engineering discipline for process modeling. Such a science would emphasize the discovery of the underlying principles for process design and analysis, for example, specifying the principles that can be used to achieve enterprise integration.

3.1.3 Research Efforts

The following research projects reflect the participants in the working group; it is not an attempt to be a comprehensive review of current research projects for PIT.

- KBSI Efforts

Knowledge Based Systems, Inc. (KBSI) is currently working on software tools to support process knowledge acquisition, process design (particularly for virtual enterprises), and the integration of process modeling and analysis. In addition, KBSI is working on foundational semantics for process modeling, i.e., Enhanced Process Interchange Format (EPIF).

How does this work address the above needs? Generic tools are applied to manufacturing and business processes, but they are weaker on services and control. Some soft issues are addressed by acquisition work. Overall, KBSI is moving towards enterprise integration.

- Process Handbook

The goal of the Process Handbook project of the Massachusetts Institute of Technology is to help organizations redesign their existing processes and to "invent" new organizational processes. The Process Handbook supports the design of new processes by composition of simpler ones and specialization from more generic ones. In this way, it approximates soft processes with libraries of "harder" processes. In addition, it forms the basis for an engineering discipline for process modeling by developing new methodologies for representing and codifying the organizational processes.

- MAVE

Metrics for Agile Virtual Enterprises (MAVE) (a National Science Foundation project) is making promising steps towards "soft logic" using situation theory as an approach to the science of enterprise and process modeling.

- TOVE

The TOVE (Toronto Virtual Enterprise) ontologies constitute an integrated enterprise model, providing support for more powerful reasoning in problems that require the interaction of multiple ontologies through the development of foundational theories based on the situation calculus. This framework provides a characterization of classes of enterprises by sets of assumptions over their processes, goals, and organization constraints. Classes of enterprises characterized in this way include material flow (manufacturing supply chains), project management, and business processes.

3.1.4 Collaborative Projects

A number of collaborative projects are underway in both industry and the research communities. Interestingly, most of the following projects are concerned with integration and interoperability.

- Process Specification Language (PSL)
  http://www.nist.gov/psl/
- Process Interchange Format (PIF)
  http://ccs.mit.edu/pif
- Workflow Management Coalition (WfMC)
  http://www.aiim.org/wfmc
- Shared Planning and Activity Representation (SPAR)
  http://www.aiai.ed.ac.uk:80/~arpi/spar/
- International Committee for Enterprise Modeling Technology (ICEIMT)
  http://www.mel.nist.gov/workshop/iceimt97/
- Global Manufacturing in the 21st Century (Globeman 21)
  http://ims.toyo-eng.co.jp/gm21/gm21.htm
- ATP1 (health care)
  http://www.hiiatp1.com

3.1.5 Summary for Break-Out Group 1

Com-munication is needed in two directions—from industry to the research community and vice versa. In the first direction, there is a need to facilitate and manage the extraction of industry needs and to communicate those to the research community. One possible method is a WWW-based clearinghouse of issues, structured as a taxonomy of industry needs. (A taxonomy was proposed in the break-out session and is shown in Fig. 1.)

In the other direction, there is a need to facilitate the transfer of new process technology from the research community to industry so that research results make an impact on industry practice. Furthermore, new process technology must be presented in a form that is easy to integrate with existing software tools and architectures.

Included in this direction is a means of providing feedback to the research community on how well the results are matching industrial problems. For example, much of the discussion in the break-out group focused on the limited expressiveness of current formalisms for process modeling. Industry must identify aspects of their problems that can serve as challenges to evaluate and extend the expressiveness of current formalisms proposed by researchers.

The discussion also highlighted the need for better coordination among projects within the research community and support for reusing the results of groups working in different domains.

3.2 Role of Research

Question: Are the issues being faced by researchers in different fields within PIT aligned and how can these researchers best work together?

Facilitator: Michael Duffey

3.2.1 Alignment of Theory-Related Issues by PSL Researchers

The participants in this group agreed that there had been significant progress in the past year in the theoretical foundations of PSL. Especially noteworthy was the alignment among participants for the approach (e.g., building ontologies) and a common terminology/ nomenclature. This was no easy task, given the quite disparate backgrounds of PSL participants in many different industry and academic domains. Much consensus has also been achieved between the PSL and the PIF communities in terms of language definition, with each group considering extensions that suit their own purposes and are unlikely to cause later conflict. There is still a clear need, however, to improve communication with EXPRESS [1], Workflow [2], ARPA Rome Planning [3], and other standards and research communities. Lastly, it is clear to the group that development of PSL is an intensely interdisciplinary problem. The gap between the "theory- based" participants and the "applied-engineering" participants is still large. A central role for the next PSL phase should be how to improve communication between these two.

3.2.2 Alignment of Scope-Related Issues in the PSL Community

Regarding domain aspects of the scope of PSL, the group agreed that there is still some confusion over whether PSL encompasses

- "Small M" manufacturing (physical fabrication processes);
- "Large M" manufacturing (concept-delivery processes for discrete manufacturing); or
- Business processes in a larger sense.

Much of the discussion and PSL examples focus on "small M." Inclusion of at least "large M" is implicit in the PSL requirements document and is in great demand in industry. The last (business processes in a larger sense) is an obvious extension of "large M" that is already taking place within manufacturing-based corporate environments. Participants agreed that, despite its many limitations, process understanding in manufacturing businesses is much more mature than most other businesses.

3.2.3 Alignment of Goals in the PSL Community

Perceptions of alignment for the goals of PSL varied considerably among members of the break-out group. Exchange of process data between legacy systems, and for emerging software environments, is probably the most tangible and immediate goal. An analogy was made with interoperability efforts in the computer-aided design (CAD) community using international specifications such as the Initial Graphics Exchange Specification (IGES) [4] and the Standard for the Exchange of Product Model Data (STEP) [5]. However, this issue should not be seen just as computer-interoperable process data exchange. A very broad industry need for process data exchange was cited for product-life-cycle data shared between large corporations and their many subcontractors and suppliers. At this time, almost all companies, large and small, have their own internal nomenclature and flowchart descriptors for defining product- development stages between concept and delivery. These unique representations create interoperability problems when development teams have to coordinate meetings and exchange written documents among multiple subcontractor participants.

Beyond the exchange/interoperability issue, it is not clear how priorities should be set for other PSL-related goals, and further prioritization will definitely impact how and which PSL participants will work together. Among the diverse goals cited were:

- Metrics on measuring efficiency of a process;
- Development of a tool to "sell" process to upper management;
- Improved diagrammatic representation of process;
- Ability to elicit and codify processes in a predictable, repeatable way.

Industry participants in this break-out group also reaffirmed that hierarchical decomposition and multiple viewpoints of process are serious problems to be addressed. One company was cited that has six levels of process description, each coming from different legacy/historical contexts with substantial differences between descriptors/terminology. Regarding multiple viewpoints, some differences are legacy-driven and some improvement is possible, but there will always be differences that will not go away.

3.2.4 Mechanisms to Improve Alignment Among PSL Participants

One concern was that the "voice of the PSL customer" needs further refinement, and a customer-requirements document would be very useful. The industry input so far is mostly from process-related software developers, not from the end-users of process information. While the initial PSL technical report from NIST was cited as a good start, it is still very limited as a customer-requirements document. It was suggested that the Malcolm Baldridge National Quality Award[1] might be a good place to start identifying forward-thinking companies to involve in the next phase of PSL development.

Another useful mechanism discussed for the next phase of PSL would be a clearly defined path towards "standardization." What is the NIST role as a broker between customer and vendor? What should the relationship be with respect to PSL issues between the U.S. and global communities? Is there a role for the International Organization for Standardization (ISO)? How will conflict resolution and change management be handled? While it is premature to answer these in detail, some general outline of a standardization path would be useful.

3.3 Role of Standards

Question: What is the role of standards in advancing the state of the art of PIT?

Facilitator: Amy Knutilla

Discussion in this group revolved around the following questions:

[1] The purpose of the Award is to promote quality awareness and to publicize successful quality strategies. For more information refer to the Uniform Resource Locator (URL): http://www.quality.nist.gov/

- What role are process information standards playing today?
- What role should they play?
- What are the other related standards activities, and how can these work synergistically?
- What is the relationship between product standards and process standards?

The discussion began by questioning our primary question, recognizing that standards typically do not play a role in advancing the state-of-the-art of technology. The primary question was revised to, "what is the role of standards in exchanging process information?" The following focus questions were added:

- Are the current standards adequate to address the scope for which they are designed?
- Are the current standards used?

While these questions were not addressed and answered individually, they served to guide the overall discussion.

3.3.1 Current Related Standards and Standards Activities

This break-out group first identified, to the best of their collective knowledge, current related standards and standards activities. These are listed below (along with brief comments):

- Workflow Management Coalition (WfMC)—generic elements of process plus domain-specific characteristics
- ISO 10303 (commonly known as STEP) Application Protocol (AP) 213 [6] and Part 49 [7]—Computer-Aided Process Planning (CAPP) to Computer-Aided Manufacturing (CAM) interoperability
- MANDATE [8] (ISO SC4 WG8)—management data for manufacturing (has limited U.S. presence)
- EXPRESS 2 [9]—allows for process modeling
- TC29 WG34 (ISO) 13399 [10]—cutting tool resources (Will functional aspects of tool performance be included in the future?)
- Process Interchange Format (PIF)—interchange format under development for business processes
- STEP AP 224 [11] and AP 214 [12] (Are other STEP APs applicable?)
- Process Plan APs
- Object Management Group (OMG)
- Product Data Management (PDM)
- Workflow RFP Manufacturing RFPII Release for Production (Routing) Process Specification Language (PSL)—neutral representation of manufacturing processes used for exchange.

3.3.2 Summary for Break-Out Group 3

Each standard serves a unique purpose. Addressing the challenge of exchanging process information necessitates that process exchange standards work together. Stated another way, no single process standard for exchange is ubiquitous. There need not be competing standards.

It is important to focus on the problems to be addressed in order to enable the exchange of process information in the manufacturing domain. Standards must specify both semantics and a vocabulary, i.e., defining semantics requires a vocabulary. Standards must recognize the existence of multiple scopes and aspects (views) of an exchange; e.g., an exchange may involve process and other types of information such as product, design, and resource information. Part of the standard must address how to "certify" or "validate" interoperability and to assure conformance to the meaning of the information to be exchanged.

This break-out group had a brief and inconclusive discussion on the different models for standards development. The "industry route" of developing and adopting *de facto* standards can be relatively fast and effective, yet there are concerns that smaller vendors can get left out. The formal route, e.g., ISO, offers a useful amount of validity and recognition, but is typically too slow in today's environment.

3.4 Role of Industry

Question: How can industry play a stronger role in setting the direction for current and future research efforts in PIT?

Facilitator: David Hollingsworth

For the purpose of this working group, "industry" was defined as PIT vendors, as well as the users (i.e., customers) of the technology. Furthermore, it was decided that setting the direction of research efforts should be appropriately confined to public research centers (i.e., academic and government research centers). It was suggested that NIST would be an appropriate organization to provide a coordination role with industry and public research organizations involved in the PIT field.

The group believed that it was in industry's interest to take an active role. Industry would benefit because PIT vendors could leverage the research results to produce better products. The users would benefit if the research efforts included activities to disseminate the knowledge about PIT to industry at large—including the users. In the other direction, incorporating user feedback

into the developing PIT effort would enable more customer-oriented products to be developed. Together, these communication efforts could help the whole PIT field by helping to grow the market.

Today, unfortunately, industry does not play a sufficient role to help set PIT research directions. Only a minimal effort is expended and only a small number of companies are involved. Instead, participation is needed in a wide range of roles. Industry should help define the general problem statement—to identify and define the technical issues, to document the existing practices, and to propose and promote a vision for the future. Industry should participate in standards bodies, review panels, and user groups. In addition, industry should review PIT-research results and provide feedback to the researchers.

Barriers to more active industry participation include the money required, the availability of people, short-term needs versus long-term vision, and lack of a shared understanding of the vision and issues. Industry should help provide the vision and help identify the issues. Widespread dissemination and ultimate sharing of the vision and issues can help overcome the barriers. In addition, letters of support—both to NIST from industry to influence project selection and from NIST to industry to show appreciation for their participation—can be very helpful. Finally, marketing the vision to industry management will also be useful.

4. Summary/Conclusions

The primary goal of the PIT Workshop was to provide an open forum for researchers and industry representatives to discuss how current and future research efforts could further address the PIT needs of industry. This goal was achieved through presentations from representatives from the research, vendor, and user communities, as well as through the use of break-out group discussions to tackle the tough issues that are facing all of the communities.

Major results from the workshop highlighted the following needs:

- Bi-directional communication between industry and the research community to ensure that research efforts are truly addressing the needs of industry;
- Better coordination among projects within the research (and standards) community and support for reusing the results of groups working in different domains;
- reduction of the gap between the theoretical aspects and the applied engineering aspects of research efforts; clearer description of the scope that the PSL project is addressing;
- clear semantics and syntax in process-related standards;
- certification or validation of interoperability and the assurance of conformance for the meaning of information to be exchanged;
- more active role by industry in standards development in helping to define the general problem statement, participating in standards bodies, review panels, and user groups, by reviewing PIT research results and providing feedback to the researchers, and by providing letters of support to encourage standards work in certain areas.

The action items that came out of the workshop included:

- continued discussion by all participants about the issues presented in the workshop via an email exploder maintained at NIST;
- the creation of web pages containing pointers to existing PIT-related web sites to provide a central point with the most up-to-date information about the PIT field;
- the creation of web pages to provide a version in HTML format of the slides presented at the workshop to other interested colleagues.

Acknowledgments

The authors thank the break-out group facilitators for providing the information contained here about the discussions and results of the break-out groups.

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5. References

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